

# Climate Change Adaptation – What Should California Do?

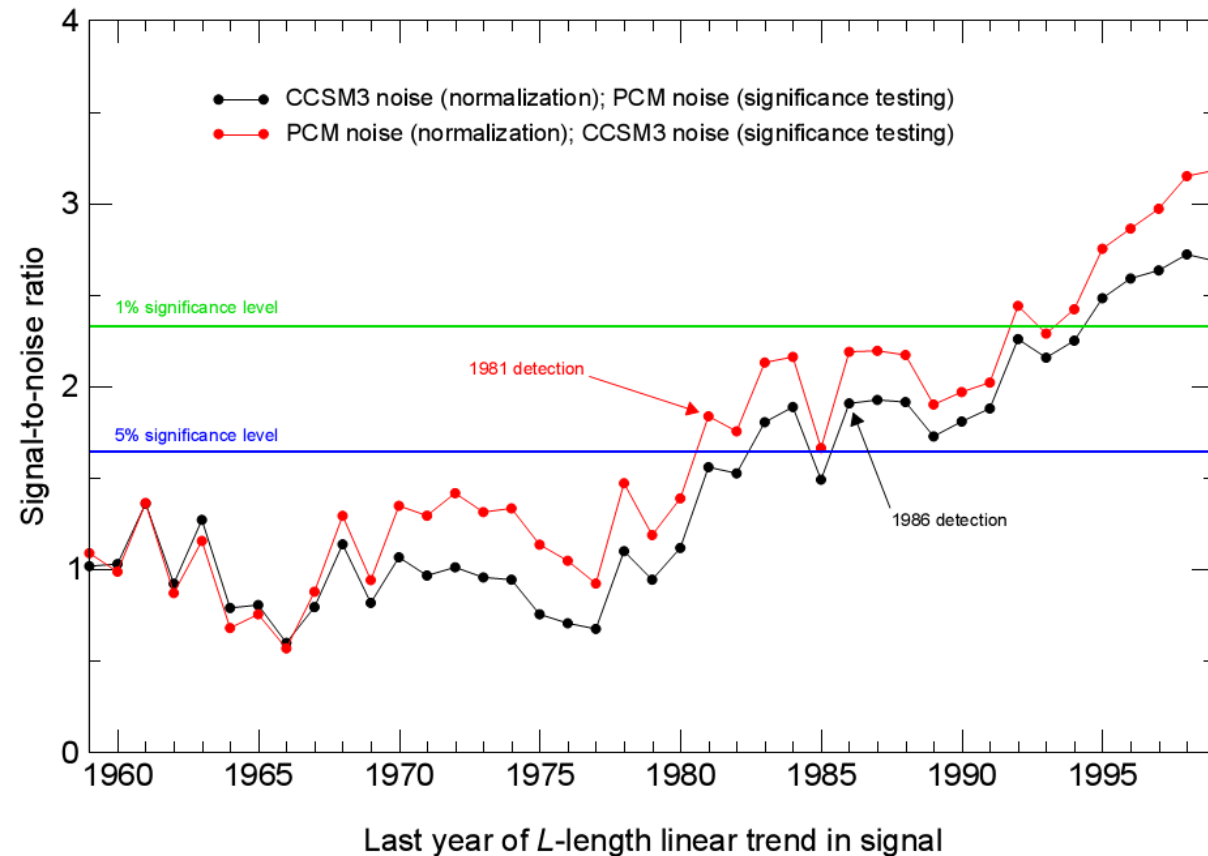
Michael Hanemann

UC Berkeley

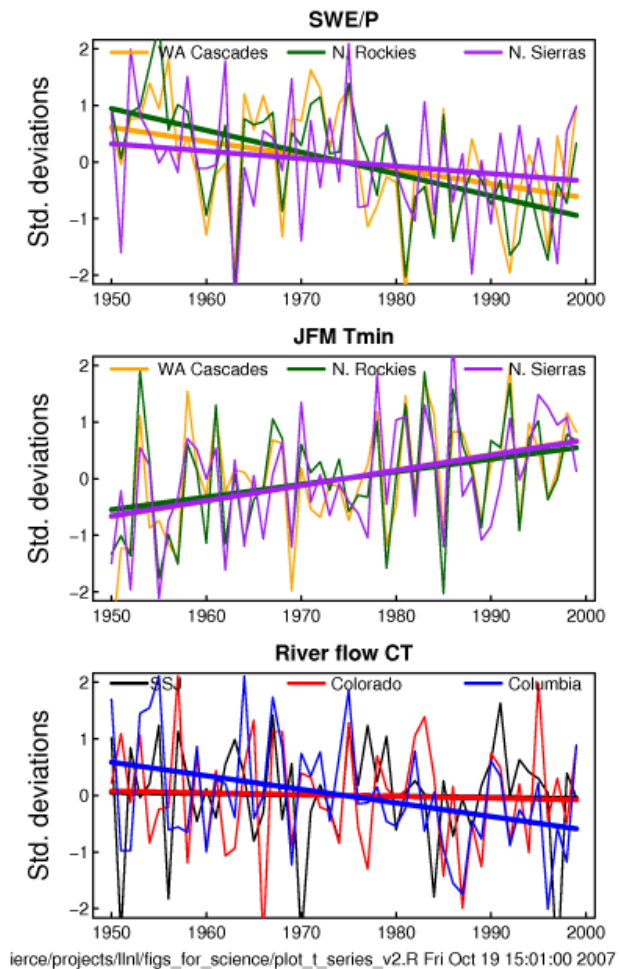
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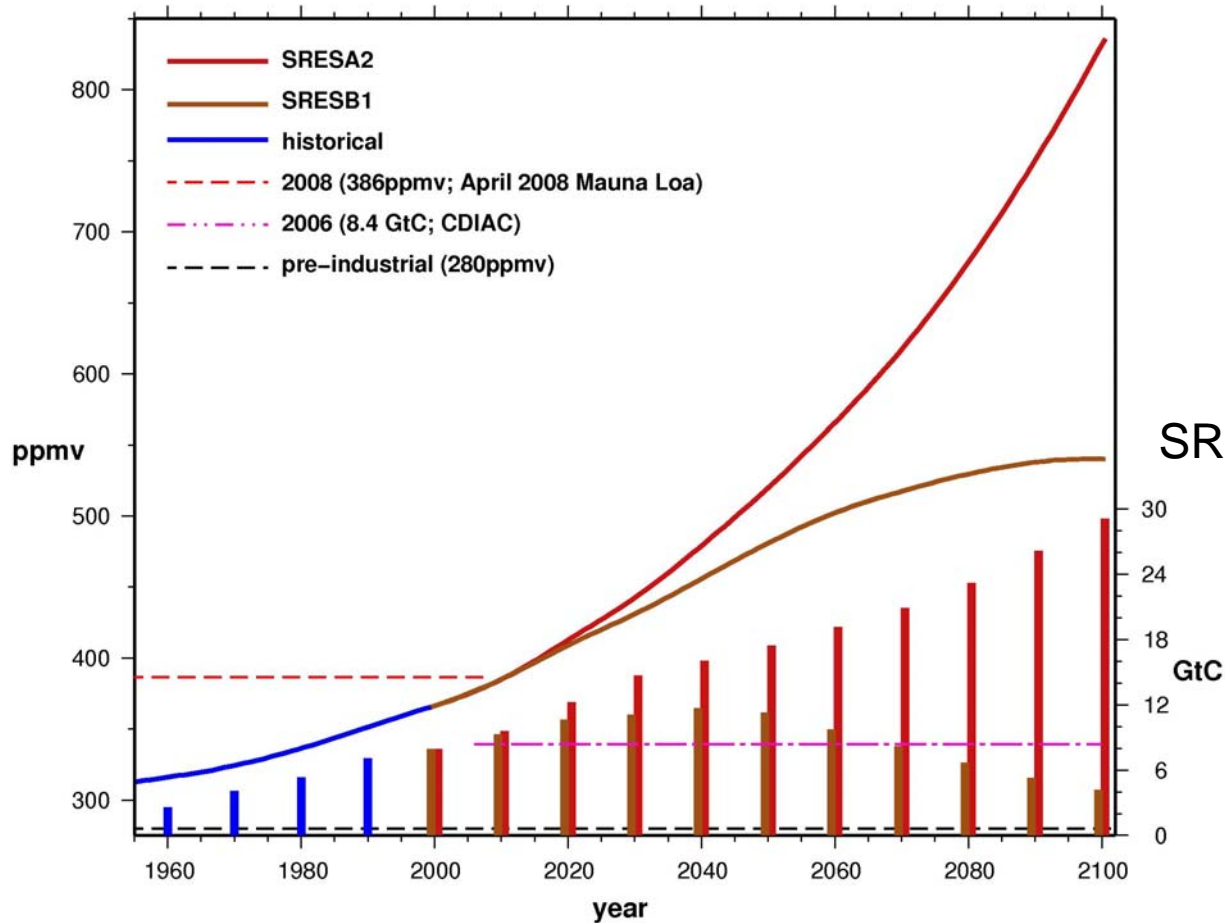


Global Climate Change  
has quite certainly been affecting  
California's climate and  
*is quite certain to continue*



## Global Atmospheric CO<sub>2</sub> Concentration (ppmv) and Carbon Emissions (GtC)

Historical Emissions from Fossil-Fuel Burning, Cement Manufacture, and Gas Flaring  
SRES Emissions from Fossil-Fuel Burning and other CO<sub>2</sub>



ppmv: parts per million by volume

GtC: Gigatons of Carbon, 1 GtC corresponds to ~3.67 Gt CO<sub>2</sub>

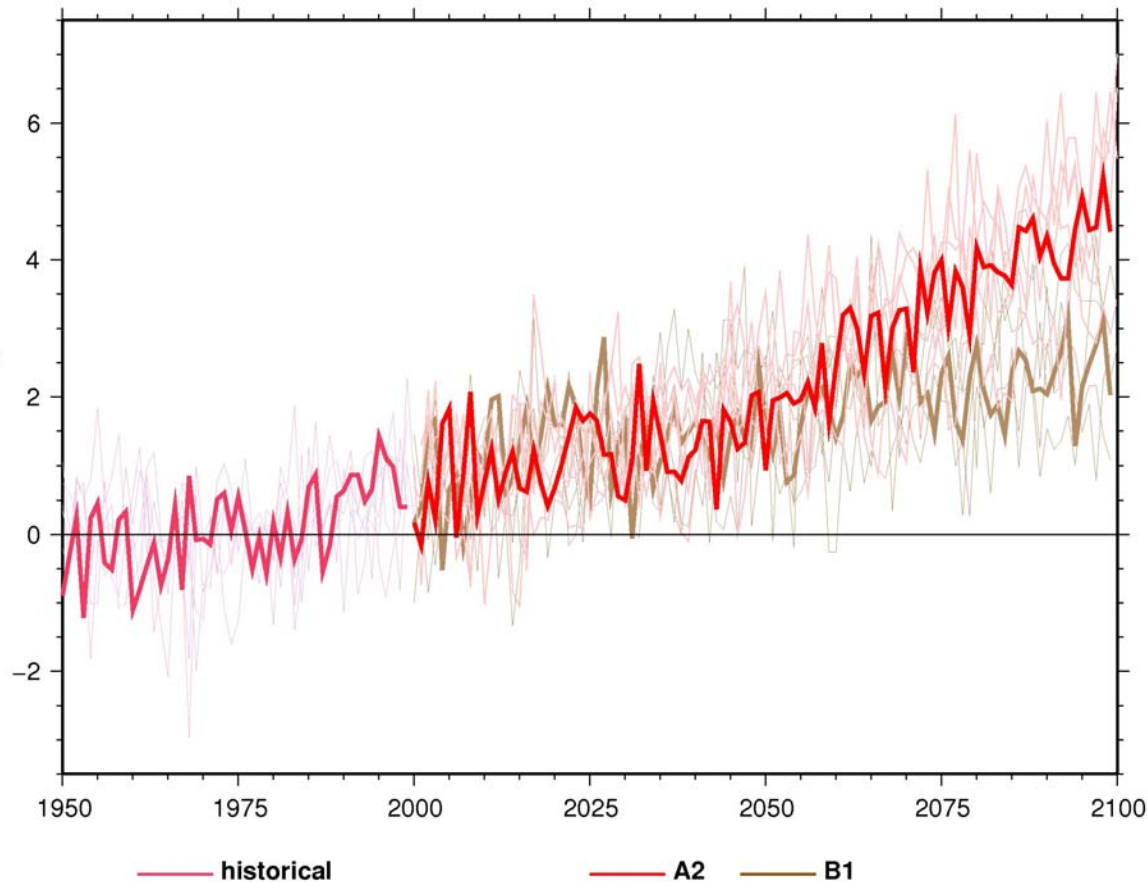
## CO<sub>2</sub> emissions and concentrations SRESB1 and SRESA2 Scenarios

Recent emissions have exceeded SRESA2 rates. For illustrative purposes, in this talk we will use an A2-driven GCM simulation

## Annual Temperature Projections, Sacramento area

CNRM CM3 (bold) historical, SRES A2 and SRES B1  
Departure from 1961–1990 historical mean

global surface air temperature

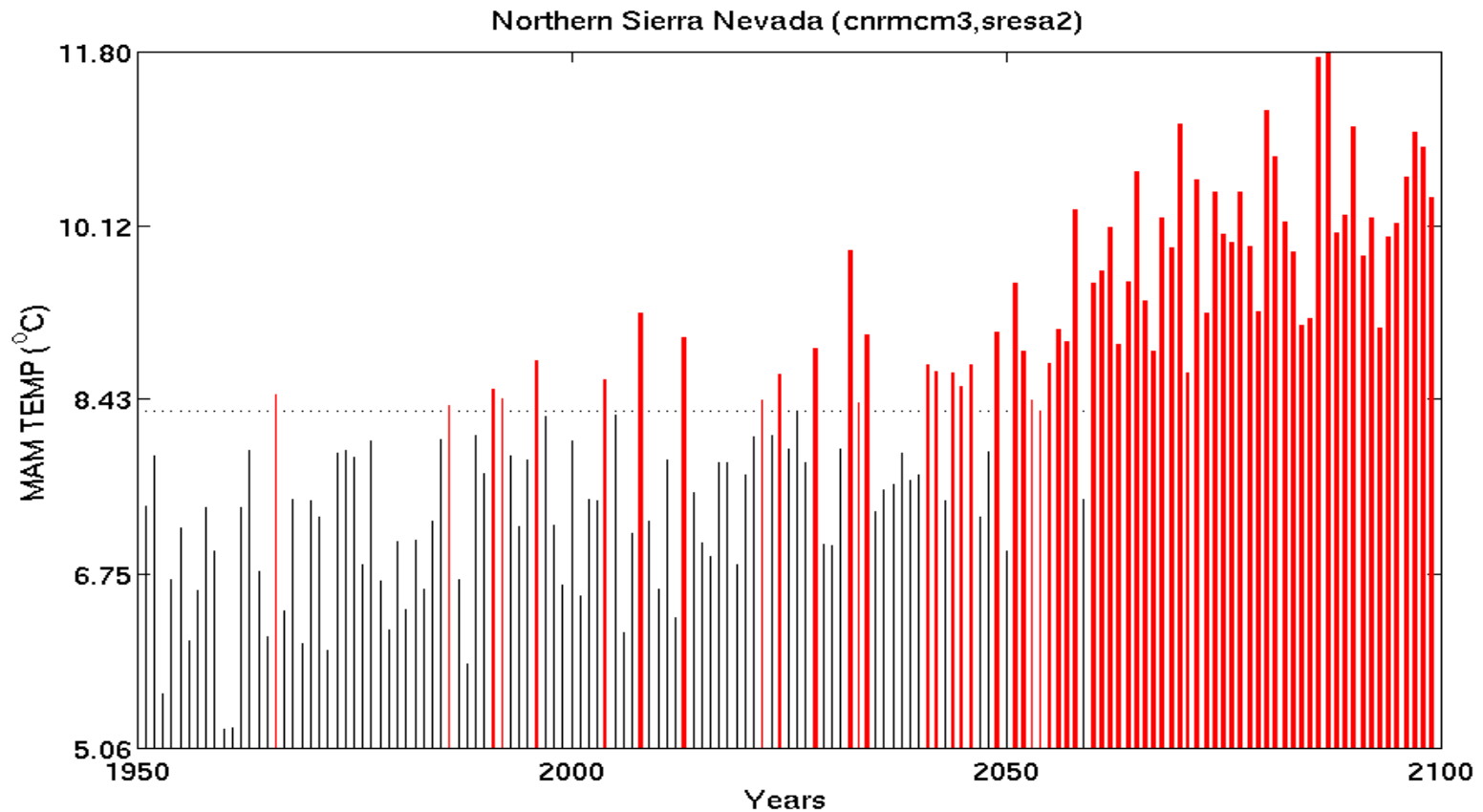


CNRM A2(red)  
and  
CNRM B1 (brown)

CNRM CM3.0 --- GFDL CM2.1 --- MIROC3.2 (med)  
MPI ECHAM5 --- NCAR CCSM3 --- NCAR PCM1

we follow CNRM A2 (and GFDL A2) scenario  
and consider when and how often  
some important *thresholds* are crossed

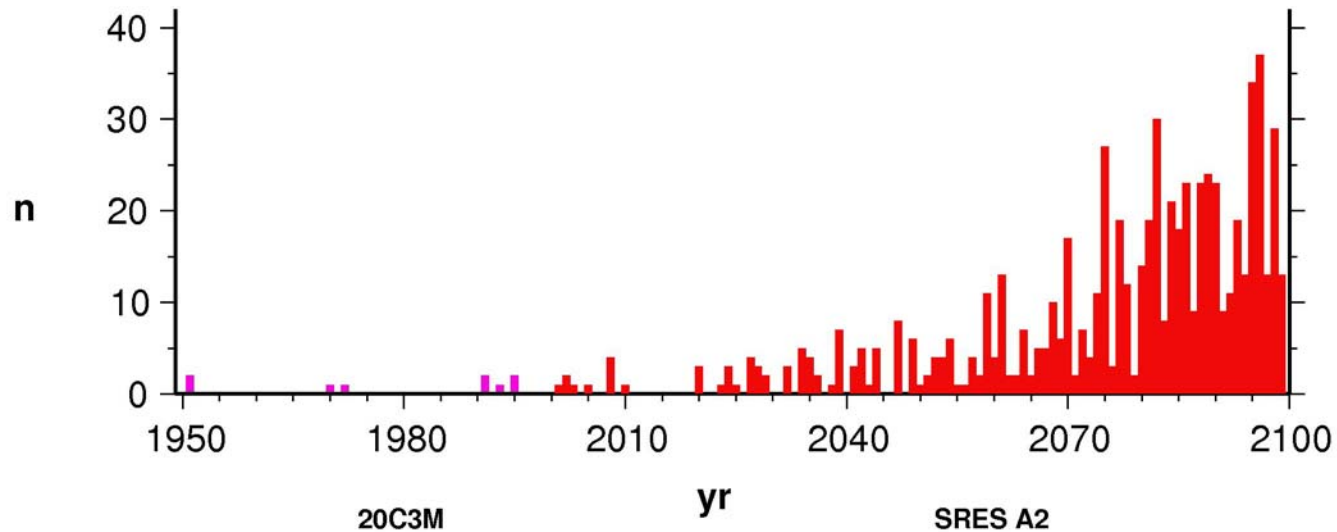
*Illustrations and Analyses thanks to Mary Tyree and Tapash Das, SIO*

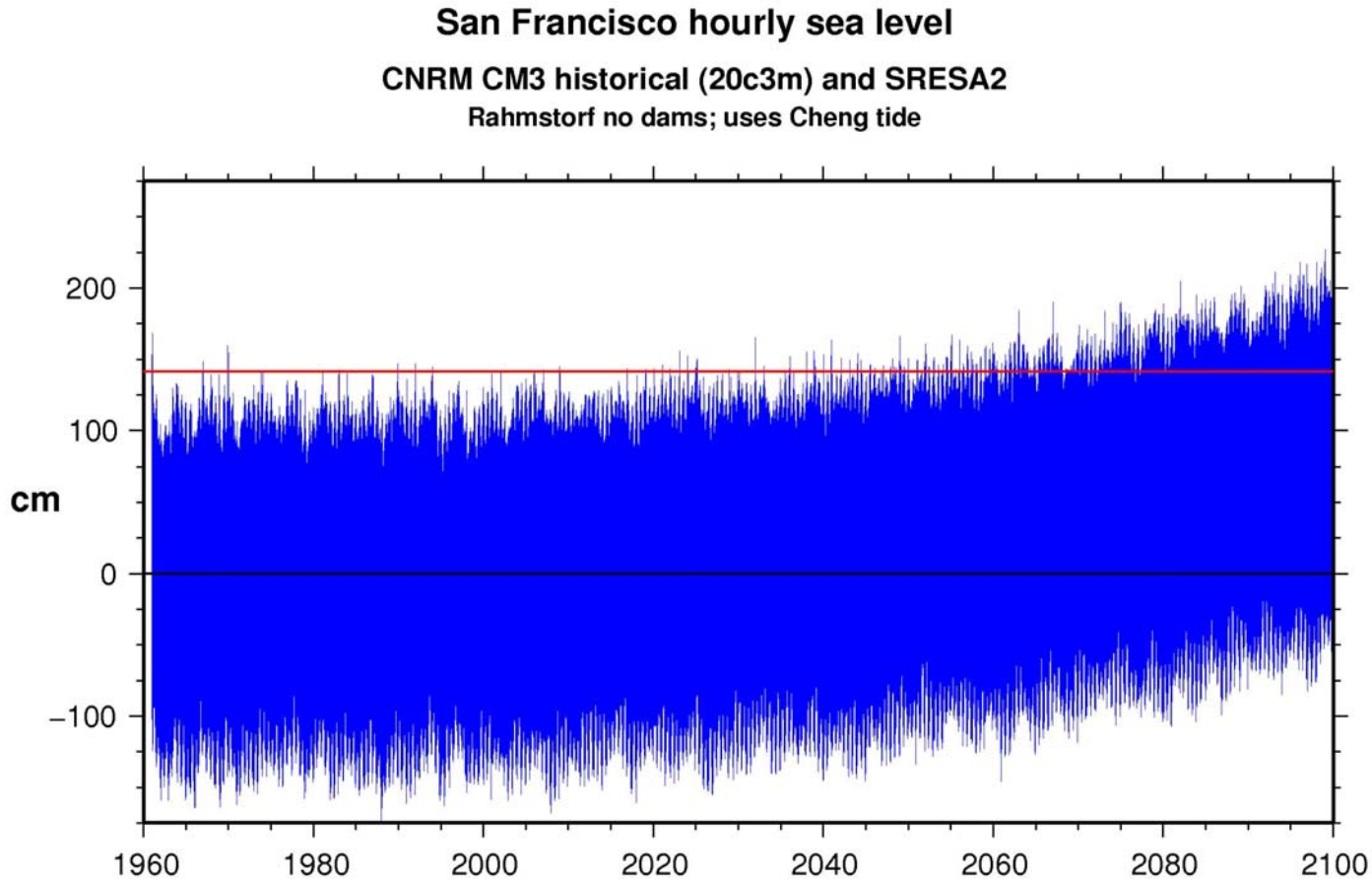


Northern California spring temperature CNRM A2  
90th percentile years (1961-1990) shown in red

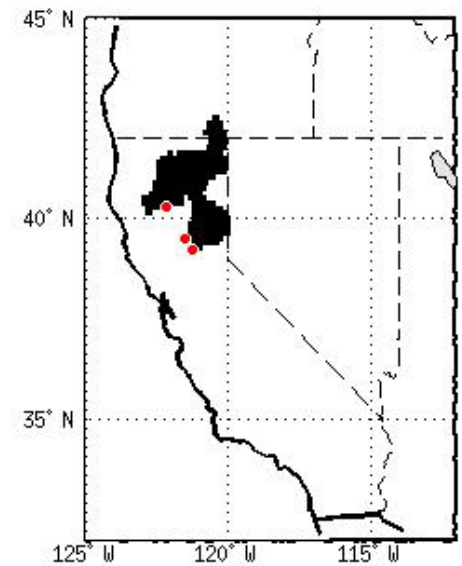
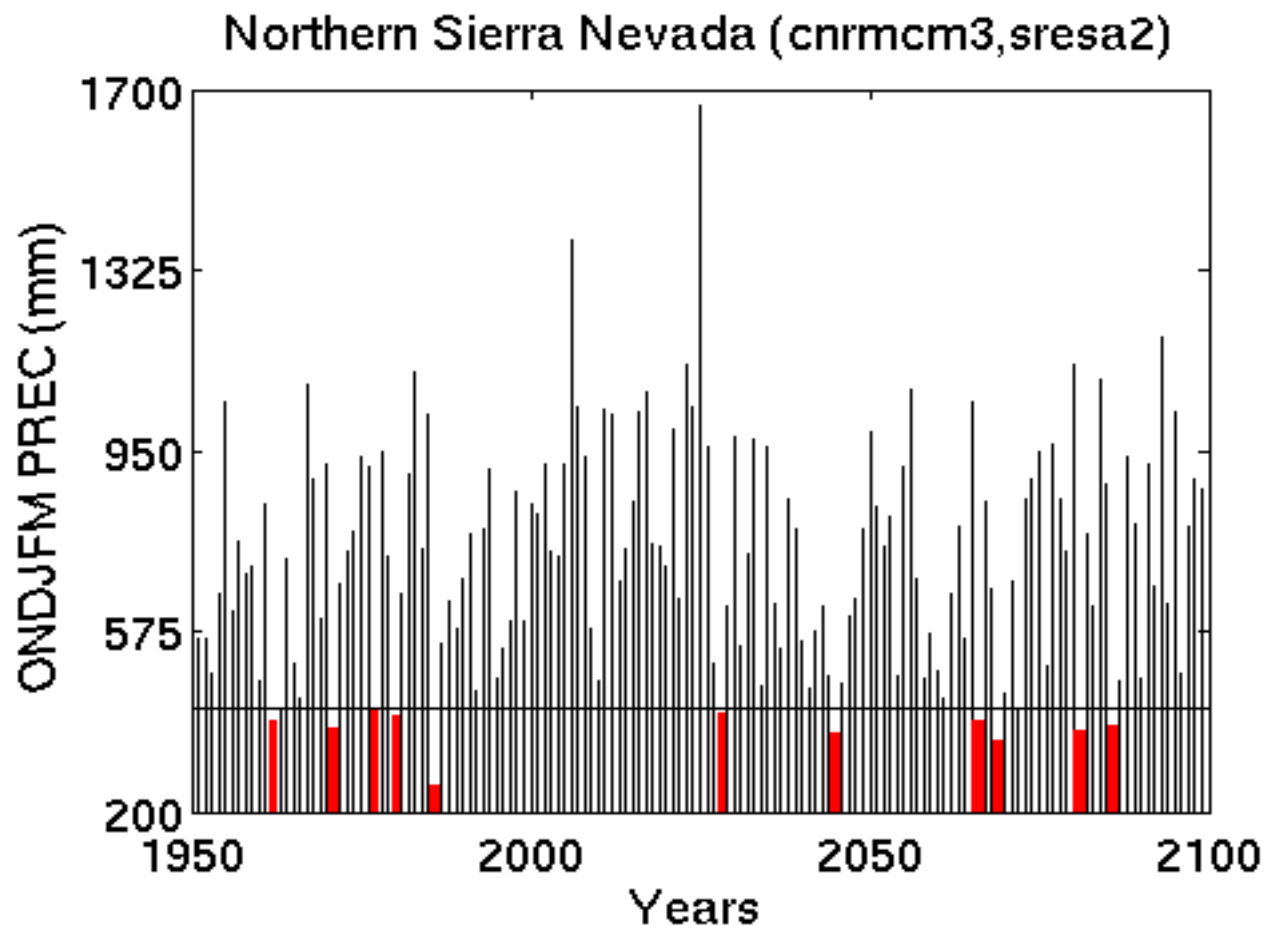
# heat waves from CNRM A2

**Days exceeding 1961–1990 99.99th %ile Tmax**  
**Sacramento region MJJAS**  
CNRM CM3 37.5°C (99.5°F)



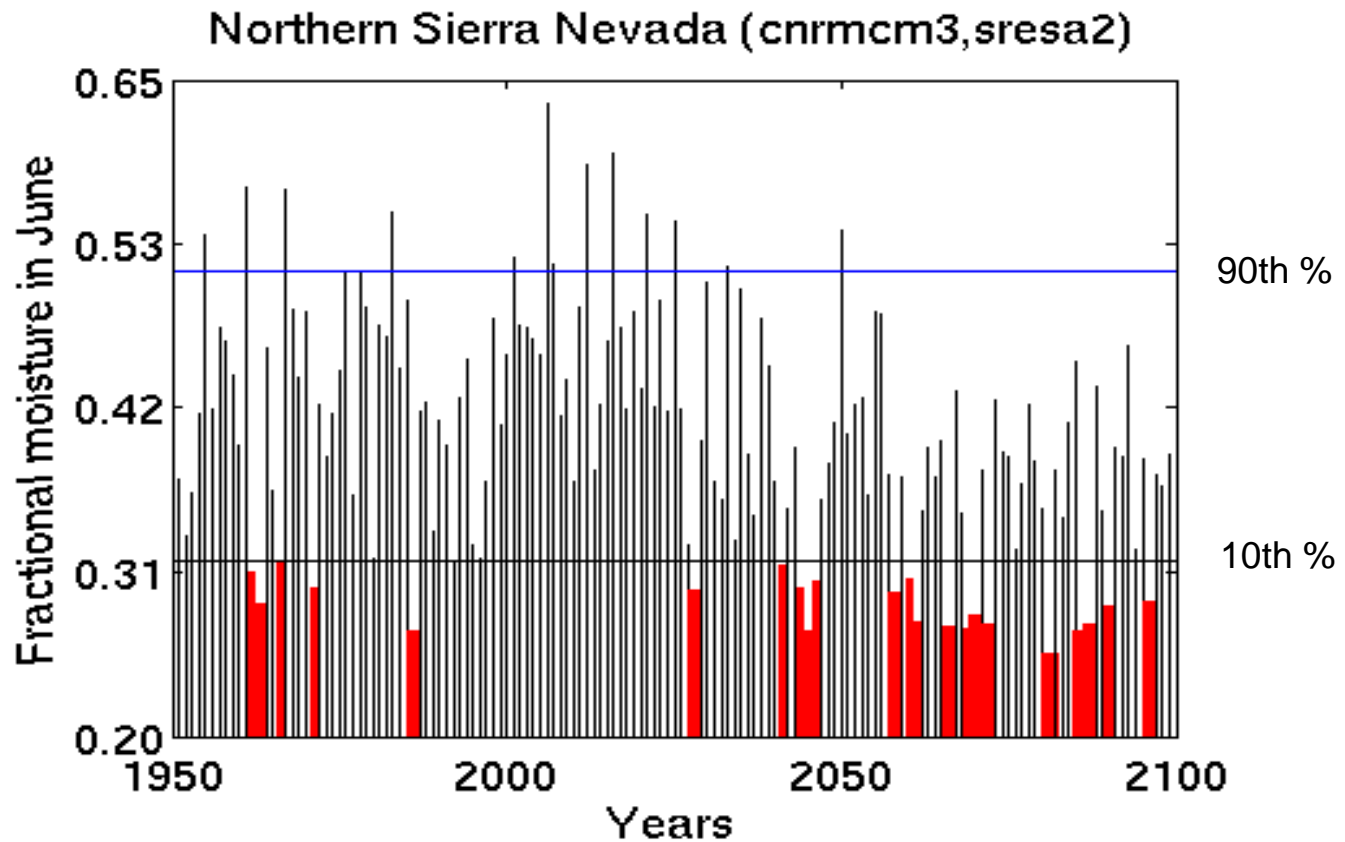


San Francisco sea level CNRM A2 using Rahmstorf scheme  
99.99th level (1961-1990) shown in red



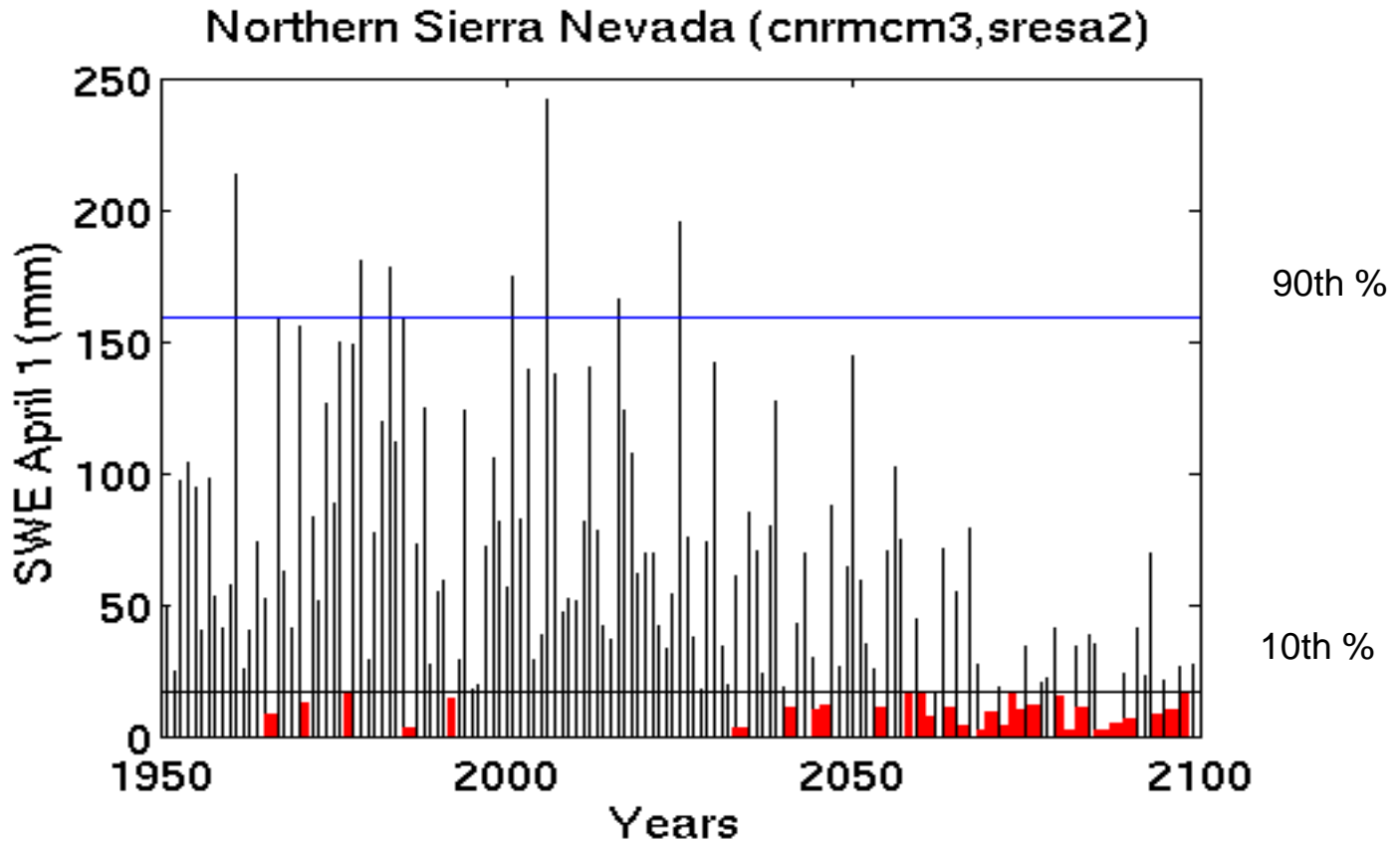
October-March precipitation CNRM A2

10th percentile years (1961-1990) shown in red



## Soil Moisture (June) CNRM A2

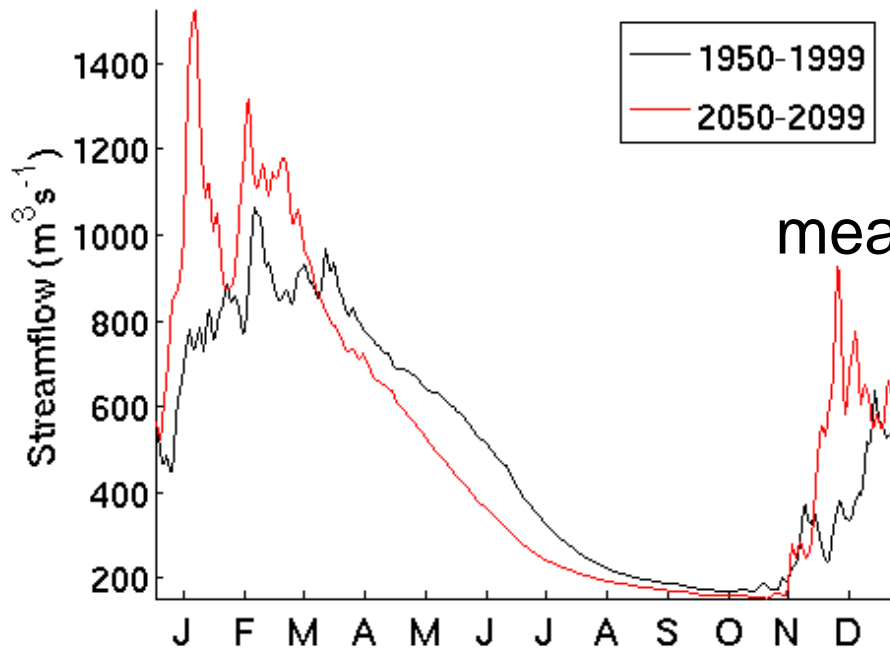
10th percentile years (1961-1990) shown in red



## Snow Accumulation (April 1) CNRM A2

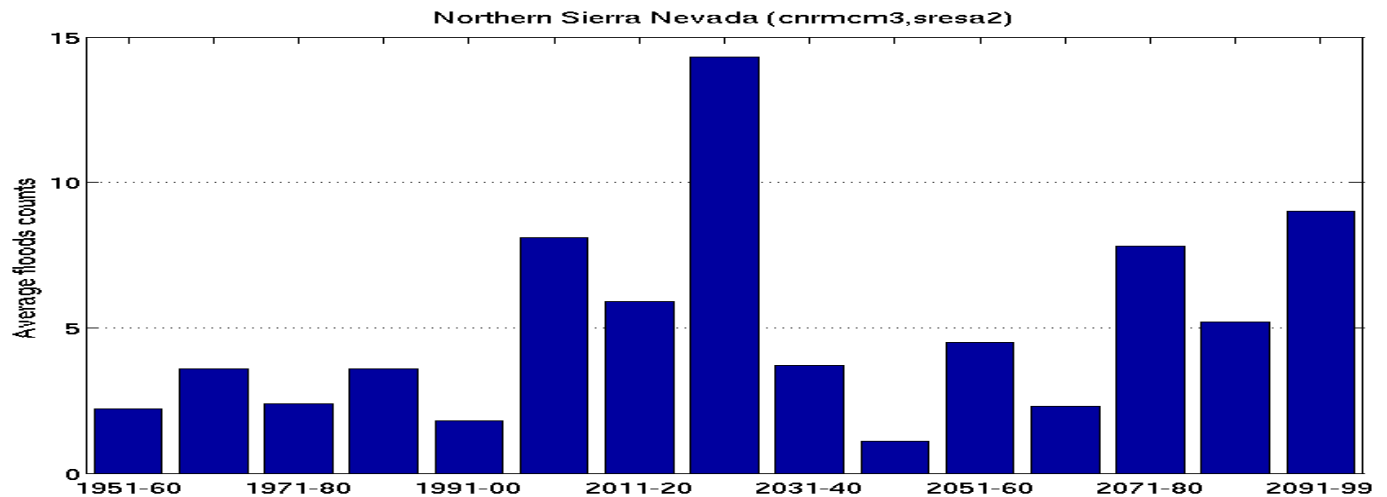
10th percentile years (1961-1990) shown in red

Northern Sierra Nevada (cnrmcm3,sresa2)



mean hydrographs CNRM A2  
Northern Sierra becomes  
more flood-prone

99th percentile streamflow events come twice as often



and now  
the economic and policy story  
from Michael

# Adaptation

- The issue is less whether adaptation will or will not occur but, rather,
  - How promptly will it occur
  - How costly will it be when it does occur
  - How perfect will it be in offsetting the climate induced changes

# Economics of adaptive response

- In economic theory, adaptation is instantaneous.
- What distinguishes the real world from the economic theory of adaptation is:
  - There is not a single actor but multiple actors. Most adaptation is local.
  - Adaptive action is mediated by institutions which govern the allocation of costs and benefits and the pace of decision making.
  - The facts of climate change and potential adaptations are not known with certainty, nor are they agreed to by the parties involved.
- These influence both the timing and the nature of the actions that occur.

# The timing of adaptation

- Before an action can occur, an agent has to perceive a reason for undertaking the action.
- This underscores two potential obstacles to timely or effective adaptation: the lack of perception of a need for action, and the lack of perception of a benefit from the action.
- Whether and when a problem is perceived by a decision maker is likely to vary.
- Public policy can influence both the awareness of a need for action, and the payoffs from action.

# Pre-requisites for adaptation

- Monitoring and measurement
  - To establish a baseline of resource use etc
  - To measure pace of change
- Ability of property rights and other institutions to accommodate consequences of climate change
- Governance mechanism for collective action
  - To undertake public (as opposed to private) adaptations
- In all of these, California is doing a poor job.

# Measurement

- In California, we do not measure or monitor surface water diversions by most users.
  - This undermines our theoretical appropriative rights system of water allocation.
  - An informal (local) system of water allocation without measurement may work fine with the status quo, but can be highly counterproductive in the event of a change in climate regime.
- We also have not firmly quantified many surface water rights
  - If we don't know who is using how much, and we don't have a good baseline of water rights, how do we manage the change in stream flow?

# Groundwater

- In many areas of California, surface water users also have access to groundwater, and will increase groundwater pumping as an adaptation to reduced surface water availability.
- Conjunctive use – storing surface water in aquifers – is in principle an attractive alternative to above ground storage.
- California is the only state in the American West which does not regulate or measure groundwater extraction.

An invitation for a train wreck.

# Changing property rights

- Two competing principles in water rights
  - Prior appropriation
    - Based purely on historical priority in use
  - Equitable distribution
    - Allocation based on principles of equity, regardless of prior history of use
- Which should be applied with climate change is partly a philosophical issue
- But, also a practical issue
  - The existing state of appropriative rights in California hardly renders it prepared for climate change.

We need to decide how we intend to handle future changes in the timing of streamflow

# Australia's experience

- Australia's recent experience has been that water markets *per se* are not an effective response to water scarcity.
- It turned out to be necessary to first reform water rights, changing from a right to extract an absolute amount of streamflow to a right to a proportional share of inflow.
- The view there is that this creates a better – and more viable – pattern of risk sharing.

- Property rights for land and protection against sea level rise
  - Who will pay for the construction of sea wall?
  - Should compensation be offered if land is excluded from a publicly financed sea-wall protection area?

These are examples of legal/policy issues that need to be decided ahead of time.

# How quickly is adaptation implemented?

## Hurricane Katrina

- In 1955, USACE starts planning for flood protection in New Orleans.
- In 1962, USACE completes comprehensive flood protection plan. No action is taken.
- 7 weeks after Hurricane Betsy in 1965, Congress authorizes construction of New Orleans Flood Defense System at cost of \$80 million and with completion date of 1978.
- When Katrina hit in 2005, the cost was over \$700 million and the projected completion date was 2013, with likelihood of further postponement.
- The two portions of the flood defense system that failed most comprehensively when Katrina hit were officially rated as 90% and 98% complete.

- This is very capital-intensive and long-lived infrastructure, heavily reliant on the public sector for its provision, and involving multi-jurisdictional participation and multi-jurisdictional conflicts.
- Wherever this constellation of factors occurs, it is likely to delay the implementation of adaptation and, perhaps also, impair its efficacy.
  - Lack of funds causes government to stretch out project completion
  - Inter-jurisdictional conflict slows project down

# Failure of governance

- Is the Katrina story so very different from that of the San Francisco Bay/Delta?
- From 1949 until now, California has been unable to reach a decision on the two core issues:
  - What are the actions that should be undertaken (restoration, environmental and water supply improvement, etc)?
  - Who should pay the cost?

# Two successes

- After a rocky start, Urban Water Management Plans are coming to play a useful role in California water.
- The Scenarios study is disseminating information on downscaled climate change impacts in California that is seen as useful to managers.
- Should government agencies in California (land use, transportation, public health etc) be required to submit a climate change readiness report every 5 years?

# In summary

- Dysfunctional institutional structure (incoherence, fragmentation, unresolved conflict) is a crucial impediment to adaptation.
  - We haven't done a good job with land use planning.
  - Land use, water supply, fire control, public health, etc are highly decentralized
- All the more reason to highlight Institutional reform – getting our house in order – as a precondition for effective adaptation.
- It is said that many adaptations are win-win actions that we should undertake anyway. But, the fact that we have *not* undertaken them already is grounds for some pessimism: it suggests there are systemic obstacles which may be hard for us to overcome.